

WHAT WORKS? Research into Practice

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Research Monograph # 14

How can educators support ESL learners to succeed in mathematics even as they are learning English?

Research Tells Us

- The "myth" that mathematics transcends language is detrimental to the interests of ESL students.
- While many ESL students quickly develop a basic level of "conversational" English, it takes several years to develop more specialized "academic" English.
- Encouraging students to use their home languages in the mathematics classroom appears to be beneficial.
- Low proficiency in all languages and mathematical underachievement is clearly linked and may explain some minority groups' underperformance in mathematics.

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ESL in the Mathematics Classroom

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Cynthia was born in Hong Kong. She speaks Cantonese and Putonghua; her early schooling was conducted in Cantonese. She is 9 years old and has been learning English for about 18 months. Her schooling, including in mathematics, is conducted in English. Cynthia is writing a word problem together with Helena, an Anglophone student in her Grade 5 class. Helena begins by proposing the first line. What issues of language and mathematics arise? What challenges might Cynthia face?

Helena: Cynthia has 30 dollars for ...

Cynthia: No, not for her her mum, if I bought for my mum

Helena: For her mum's present ...

Cynthia: If give my mum 30 dollar I bought nothing from her, that not make sense ...

Helena: No, I wasn't writing for your mother, I said Cynthia has 30 dollars for her mother's present ...

Cynthia: 30 dollar, I gave 30 dollar for my mum present ...

Helena: No, I didn't say give it to her ...

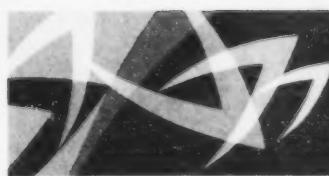
Cynthia: Then how why you ...

Helena: You have 30 dollars for your mum's present ...

Cynthia: No but I think this make sense, Cynthia has 30 dollar 30 dollar, she bought er something something something, it's cost something something from her mum present and how much she left? Is that make sense little bit?

Adapted from original data collected in the UK¹

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Languages, Language Learning and Mathematics

Characteristics of Mathematical English

Mathematical English has its own vocabulary, which can be roughly divided into three groups³:

- technical terms specific to mathematics (e.g., *multiplicand*, *quadrilateral*)
- technical terms used in mathematics that also have unrelated everyday meanings (e.g., *volume*, *product*)
- mathematical use of words adapted from similar everyday meanings (e.g., *similar*, *face*).

Mathematical English has several other dimensions, including³:

- specialized syntax (e.g., the use of words like *and*, *a*, or *if*)
- use of symbols (e.g., *3-D*)
- ways of talking and writing (e.g., word problems, writing a solution, giving an explanation)
- social factors (e.g., the use of *we* to refer to people who do mathematics, as in "We call that a pentagon.")

Imagine you are teaching Cynthia. It would be easy to think that she does not understand word problems. It may be, however, that she is confused by a word like *for*, rather than by anything mathematical. Actually, as the last line of this excerpt shows, she understands what word problems look like. Cynthia and Helena go on to write a two-stage word problem, which Cynthia then solves straightforwardly. How, then, can ESL learners like Cynthia be supported so that they succeed in mathematics even as they are learning English?

In summarizing some of the relevant research on supporting ESL learners in mathematics, this monograph will focus on two main issues. First, it will outline findings relating to the relationship between language, language learning and mathematics. What role does language play in learning mathematics? What are the characteristics of mathematical English? What difference does learning mathematics through a second language make? Second, the monograph will discuss mathematics practice in the classroom. What challenges do teachers encounter? What factors appear to be effective in supporting ESL learners in mathematics? Research relating to these questions will be summarized in the sections that follow.

What role does language play in learning mathematics?

Perhaps more than any other subject, teaching and learning mathematics depends on language. Mathematics is about relationships: relationships between numbers, between categories, between geometric forms, between variables and so on. In general, these relationships are abstract in nature and can only be brought into being through language. Even mathematical symbols must be interpreted linguistically. Thus, while mathematics is often seen as language free, in many ways learning mathematics fundamentally depends on language. For students still developing their proficiency in the language of the classroom, the challenge is considerable. Indeed research has shown that, while many ESL students are quickly able to develop a basic level of "conversational" English, it takes several years to develop more specialized "academic" English to the same level as a native speaker.⁴

If learners of ESL, like Cynthia, are to succeed in mathematics, they need to become proficient in all dimensions of mathematical English, since to some extent the structure of mathematics is reflected in the structure of its language. It is often the little words like *for* that cause the most difficulty for students. (See page 2 sidebar "Characteristics of Mathematical English.")

What difference does learning through a second language make?

Learners' home languages can play a crucial role in their learning of mathematics. Cummins⁵ suggests that students need a high degree of proficiency in at least one language in order to make satisfactory progress at school. He also proposes that students with strength in two or more languages will outperform their peers, while those without a high degree of proficiency in any language will underachieve.

Cummins' ideas have been demonstrated, in the field of mathematics, by research involving ESL students in Australia. In this research, the link between low proficiency in all languages and mathematical underachievement is particularly clear and may explain some minority groups' underperformance in mathematics (see also 7, 8). There is also some evidence that students with strengths in two languages do better in mathematics than other students.⁶

These findings refute the assumption that students' home languages are irrelevant and should be ignored. Indeed, in many cases, encouraging students to use their home languages in the mathematics classroom appears to be beneficial.^{9, 10}



Mathematics Classroom Practice and Learners of ESL

What challenges do teachers encounter?

Finding a balance between focusing on mathematics and focusing on language is perhaps the biggest challenge of teaching mathematics to learners of ESL. This balance was a key issue for teachers participating in research conducted by Adler in South Africa.¹¹ Although the situation in multilingual South Africa is rather different from that found in Ontario classrooms, some of the issues that arise for teachers are relevant. Adler highlighted several dilemmas that arose for teachers in their multilingual mathematics classrooms. One of these dilemmas – “transparency” – concerned the visibility of, or explicitness of attention to, mathematical language. This issue was raised by one of the teachers participating in the study, who reflected on an incident where a student gave an explanation to the rest of the class¹²:

Here, there is a tension between the teaching of “correct” language and the students’ understanding of mathematics. To what extent is correct mathematical English necessary to do mathematics? This incident also illustrates a second dilemma: whether or not to intervene. By intervening, the teacher could have shifted the attention of the students from the mathematics they were grappling with to the language used to explain that mathematics. Intervening could have allowed the student to give an explanation using more mathematical language, but the resulting explanation might not have been the explanation she would have given for herself. On the one hand, intervention would have disempowered her student. On the other hand, offering a language for students can empower them to develop their thinking.

We can see how these dilemmas may arise with a student like Cynthia. If she and Helena understand each other, does it matter if their use of the language of mathematics is idiosyncratic? If a teacher had intervened in their discussion and clarified the confusion caused by the word *for*, Cynthia might not have articulated her own fairly sophisticated idea of what the word problem should look like.

What factors appear to be effective in supporting ESL learners in mathematics?

In a study conducted in the United States, Khisty¹³ compared the mathematics culture of two different English-Spanish bilingual second grade classrooms. In one, the teacher controlled discussion through the use of repetition and choral responses. Khisty feels this approach depersonalizes mathematics for the students. In the other, mathematics was negotiated through discussion, challenge and debate. This environment frequently required students to explain their ideas and to draw on previous experience to make sense of new situations. Khisty believes that the culture of this second classroom led students to make mathematical meaning for themselves by interacting with both the teacher and other students. Her observations led her to conclude that the “myth” that mathematics transcends language is detrimental to the interests of ESL students.

Similarly, my own research suggests that learners of ESL find word problems less perplexing if they are able to relate them to their own experiences, as Cynthia does in the excerpt.¹⁴ Furthermore, students need opportunities to discuss problems in order to make sense of them. This is not to suggest that teachers must design problems based on the lives of their students; it is difficult for any teacher to be familiar with students’ many different cultures, languages and backgrounds. Rather, activities can be designed that allow learners to bring their experiences and interests to mathematics. In Cynthia’s case, she is able to incorporate aspects of her daily life into the word problem and, in the process, to develop a better understanding of word problems, as well as of mathematics.



Implications for Teaching

1. Be aware of the specific linguistic demands of mathematics and, where appropriate, highlight and discuss aspects of mathematical English with your students. What aspects of mathematical English arise in your class? What do your students find problematic or confusing?
2. Find out about ESL students’ home languages, their levels of proficiency, and their study of mathematics in other languages. What languages do they speak? How can you enable your ESL students to use their languages as resources for the learning of mathematics?¹⁴
3. Promote ESL students’ mathematical meaning-making through problem solving, problem posing and opportunities for discussion. What mathematical discussions do your ESL students currently engage in?

Suggestions for Further Reading

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The Multiliteracies website: www.multiliteracies.ca/index.php

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References

Implications for Teaching

Teaching mathematics to ESL learners is complex. These students bring with them a wide range of languages, proficiencies, experiences and expectations. While, in the light of this complexity, specific recipes are unlikely to be universally applicable, some broad principles can be suggested as starting points for reflection: (1) be aware of the specific linguistic demands of mathematics and, where appropriate, highlight and discuss aspects of mathematical English with your students; (2) find out about ESL students' home languages, their levels of proficiency, and their study of mathematics in other languages, and (3) promote ESL students' mathematical meaning-making through problem solving, problem posing, and opportunities for discussion.

Word problems are often challenging for students, particularly ESL students like Cynthia. In tests, she generally got them wrong. However, when given the opportunity to explore how word problems work, Cynthia found them straightforward, she was able to develop explicit understanding of an aspect of mathematical English, as well as of the relationship between words and mathematics. She succeeded, in part, through making them her own.

There is not necessarily a correct response to the dilemmas mentioned above. However, one general approach does emerge from research findings. If children are to learn mathematics, there needs to be a focus on mathematical meaning-making.

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